2014

Plague Depopulation and Irrigation Decay in Medieval Egypt

Stuart Borsch
sborsch@assumption.edu, sborsch@assumption.edu

PLAGUE DEPOPULATION AND IRRIGATION DECAY IN MEDIEVAL EGYPT

STUART BORSCH

THE FIFTEENTH-CENTURY EGYPTIAN chronicler al-Maqrīzī provides us with a substantial account of the Black Death in his historical narrative of several thousand pages: the *Kitāb al-sulūk lī-ma 'rifa duwal al-mulūk* (*The Book of Methods for Understanding the Kingdoms [of the World]*). Al-Maqrīzī was a market inspector (*muhtasib*) as well as a prominent historian. His extensive works have therefore provided modern scholars with a great deal of information about Egypt's economic history. Concerning the plague's arrival in Egypt, al-Maqrīzī's narrative describes a sequence familiar to historians of the Black Death: how, in 1347 CE, a pestilence "worse than any seen before in the Islamic world" began with a ship full of corpses drifting into Alexandria. There were a few sailors still alive; they died soon after—and Egypt's experience with the Black Death began (al-Maqrīzī, *al-Sulūk*, 2: 772–73).

Al-Maqrīzī reports that in Alexandria the plague began killing a hundred people a day, and that the death toll subsequently doubled to two hundred a day. As the plague outbreak reached its peak, there were mass funerals for as many as seven hundred people. The plague then spread throughout the Nile Delta, where "no one was left to gather the crops." In the city of Bilbays at the eastern edge of the Delta, al-Maqrīzī reports that "mosques, shops and lodges were left empty" (al-Maqrīzī, *al-Sulūk*, 2: 777–79). When the plague struck Cairo, the sultan and leading members of the ruling regime fled the city, as mass prayers were held in the mosques and the cemeteries. When the plague reached its peak around December of 1348, it was reported that something like 7,000 people died per day. The plague finally abated the following February; in the quiet that followed, Cairo was like a graveyard, still and empty (al-Maqrīzī, *al-Sulūk*, 2: 780–84).

Scenes of devastation like that of Cairo in February 1349 were to become all too common in Egypt. Plague depopulation in the instance of the Black Death had a deep and long-term impact on Egypt's economy. This article examines the manner in which plague shaped the economic history of Egypt. It assesses the relative scale and scope of rural mortality and argues that plague depopulation led to the collapse of Egypt's economic infrastructure; the analysis that follows is intended to show exactly

ARC MEDIEVAL PRESS THE MEDIEVAL GLOBE 1 (2014) pp. 125–156

how and why this happened. In so doing, this essay illustrates an important lesson to be learned from the historical study of plague: the economic impact of massive depopulation could vary greatly from region to region throughout the affected areas of the medieval globe. These economic responses to exogenous demographic shocks were, moreover, shaped by and dependent upon diverse social, institutional, and environmental variables. In this case, emphasis falls on the dependent variable of geography; but other variables, such as political institutions rooted in social structures, also demand attention. While it might sound obvious that we should keep our theoretical expectations flexible, it is all too easy to fall into the comforting conceptual trap of familiar and well-established trajectories: that is, the well-known European pattern of falling prices, rising wages, social mobility, and improved nutrition discernible in the aftermath of the Black Death. Egypt offers a very different picture of the outcomes stemming from rapid, plague-induced demographic changes.

Studying the Economic Impact of the Black Death in Egypt

The Black Death of 1347–50—and the cycles of plague that followed it—brought depopulation and change not only to Egypt but also to the Middle East in general. While it is accurate to say that this process of transformation and evolution is only partially understood, it is worth examining what progress has been made; the following is a review of the scholarship (largely focused on Egypt) that pertains to economic developments influenced by plague depopulation. The work of Eliyahu Ashtor (1949, 1969, 1976, 1977) is the best place to start. Ashtor's broad conclusion that the Black Death was devastating to Egypt has never been seriously challenged, and he is still the most cited source for the specifics of economic decline in this period. In 1970, Abraham Udovitch (together with Robert Lopez and Harry Miskimin) summed up what was known about the economic trajectory of Egypt in the late Middle Ages (Lopez, Miskimin, and Udovitch 1970). Udovitch concluded that economic decline was quite severe during the 1350 to 1500 interval. Around the same time, studies of monetary transformation by Jere Bacharach (1971 and 1983) drew deserved attention to the problems posed by the adoption of copper currency in Egypt during the late fourteenth and early fifteenth centuries. The formal study of the Black Death in Egypt began with Michael Dols (1977). In his book, Dols included a section on the economic impact of the Black Death. As was the case with Ashtor and Udovitch, his conclusions about the economic impact of plague depopulation were altogether negative. Later work by Dols (1979, 1981) focused primarily on the plague outbreak of 1430. As the data that we have for this outbreak is much more extensive than that for the Black Death itself, Dols made a case study of Cairo and concluded that overall mortality in that city was on the order of 90,000.[1]

After Dols's work, there were no studies dedicated specifically to the Black Death in Egypt—or the Middle East—until my own comparative monograph (Borsch 2005). However, there were a number of studies in the economic history of Egypt that examined the problem indirectly. The work of Boaz Shoshan (1983) on grain prices, from which he considerably expanded the data on prices and exchange rates for late medieval Egypt, focused on the role of monetary factors in the economic turbulence of the 1400s. Shoshan was one of a series of scholars—Giles Hennequin (1974), Adel Allouche (1994), Warren Schultz (1998, 2011), and John Meloy (2001)—who studied various aspects of the monetary system in the wake of the Black Death. Among this group there seems to have been a quiet consensus that the monetary woes of the 1400s were in many ways bound up with falling economic production. Carl Petry (1994) devoted a chapter of his work to the economic trajectory of Egypt in the post-Black Death period, painting a bleak picture of economic events, especially when it came to the political economy of corruption and its impact on the economy as a whole. From a very different perspective, Sato Tsugitaka (1977) was really the first scholar who studied the Egyptian irrigation system during the Mamluk period, and his work is indispensable for anyone studying economic changes in the rural economy in the interval between 1347 and 1517.

Adam Sabra's work (2000) indirectly addresses the subject of plague depopulation via an examination of famine relief in the Mamluk period of rule (1250–1517). His detailed analysis of Egypt's inflationary cycles is an indispensable guide to the economic trajectory of Egypt at this time. At roughly the same time, two Egyptian historians produced detailed and innovative studies of Egyptian economic life that included a great deal of detail about the rural economy of Egypt after the Black Death. 'Imād Abū Ghāzī (2000), a historian who produced what was effectively the first archive-based monograph dedicated to the rural economy of Egypt, explored the changes in the agrarian economy that arose because of land sales conducted by the cash-strapped Circassian Mamluk regime.

1 Dols (1977: 204–12) initially examined the outbreak of 1430 and provided a table that attributed 91,845 deaths to plague for that year, a figure in close proximity to that given by the fifteenth-century chronicler Ibn Taghrībirdī, who had estimated 100,000 deaths (Popper 1954–63, 4: 72, 181). Dols's later analysis of this epidemic (1981) included a thorough re-examination of population levels for Cairo.

The work of ʿĀmr Najīb Mūsā Nasir (2003) addresses a host of hitherto overlooked aspects of the rural economy, breaking ground in terms of the depth and detail given to rural economic change in the wake of plague depopulation. In terms of archival work on the rural economy, it should also be noted that the Japanese scholar Daisuke Igarashi (2006, 2008, 2010, and forthcoming) has extensively investigated archival collections of *waqf* documents (created by formal institutions established by charitable donation) in order to study agrarian developments; his forthcoming monograph on the political economy of *waqf* foundations deals with the economic change related to plague depopulation.

Meanwhile, Sevket Pamuk (2007) has taken up the subject of east-west divergence and its relationship to plague depopulation. Since then, he has (with Maya Shatzmiller) published analyses that study wage trajectories following plague outbreaks (Shatzmiller 2012; Pamuk and Shatzmiller 2014). Two other recent contributors to this area of economic history are the Malaysian scholar Wan Kamal Mujani (2008 and 2011), who studies economic developments at the very end of the Mamluk period, and the Swedish economist Johan Söderberg (2006), who has produced a new and novel examination of prices, an examination that employs methodological tools new to the study of the Black Death in the Middle East.

Another recent work in Arabic, indispensable for anyone studying the economic impact of plague depopulation in Egypt, is that of Muhammad al-Zāmil (2008). This book is full of insightful observations and detailed analysis of economic developments—particularly developments in the rural sphere. Perhaps the most innovative recent study is by Julien Louiseau (2011). In *Reconstruire la maison du sultan, 1350–1450: ruine et recomposition de l'ordre urban au Caire*, Louiseau conducts a detailed mapping of Cairo that examines the areas of the city most affected by the *khirāb*, or economic decline of Egypt. Using a broad archeological reconstruction of fifteenth-century Cairo, this massive two-volume work studies the aftermath of the Black Death and its effects on the built environment, including graves as well as ruined palaces, mosques, and housing structures.

Finally, looking at the subject of plague in the longer term, there is new work by Alan Mikhail (2008, 2011, 2013) and Sam White (2010) on Ottoman Egypt. Mikhail, whose work studies the trail of plague mortality stretching all the way to the nineteenth century, focuses attention on the environmental history of plague, and his innovative use of archival court records gives him a unique perspective on the disease's long-term tenure in the eastern Mediterranean. Long after plague had been banished from Europe it endured in the Middle East, and it continued to haunt Egypt, with outbreaks recurring approximately every nine years for over half a millennium, from 1347 to 1894 (see also Varlık 2014, in this issue).

Measuring Rural Depopulation

The Black Death was thus the first of many blows that struck the Egyptian population; cycles of plague outbreaks continued into the 1400s and well beyond—and some of these outbreaks were nearly as bad as the Black Death itself (Dols 1977: 305–14).[2] The many outbreaks of the fifteenth century carried away enough victims that they left deep scars in the collective memory. An account narrated by al-Maqrīzī (*al-Sulūk*, 4: 227) describes the outbreak of 1412 in the following terms:

> فخربت الإسكندرية و بلاد البحيرة و أكثر الشرقية و معظم الغربية و الجيزة و تدمرت بلاد
> الفيوم و عم الخراب بلاد الصعيد بحيث بطل منها زيادة على أربعين خطبة كانت تقام في يوم
> الجمعة. و دثر ثغر أسوان – و كان من أعظم ثغور المسلمين. فلم يبقى به أمير و لا كبير و
> لا سوق و لا بيت. و تلاشت مدائن الصعيد كلها. و خرب من القاهرة و ظواهرها زيادة على
> نصف أملاكها. و مات من أهل إقليم مصر بالجوع و الوباء نحو ثلثى الناس.
>
> (Alexandria was laid waste [by these troubles] and so was [the Nile Delta province of] al-Buḥayra. The greater part of [the province of] al-Sharqīya was ruined, and the majority of [the two provinces] al-Gharbīya and Giza were desolated. The [province of] the Fayyum was devastated. Destruction was widespread in Upper Egypt as well – so much so that more than forty sermons that were held on Fridays were abrogated. *[The intent here is to convey that more than forty villages/towns large enough to have a congregational mosque were abandoned.]* The port city of Aswan was destroyed, and it was once one of the greatest of Muslim port cities; now nothing remains in it of amirs, influential people, marketplaces, or houses. Most of the cities of Upper Egypt have been obliterated. Cairo and its outskirts have lost half their wealth. And two-thirds of the population of Egypt has been wiped out by famine and plague.)

Al-Maqrīzī is trying to describe the scale and scope of economic and demographic devastation, though a mortality of two-thirds was probably only witnessed at times and in places where plague outbreaks were at their most intense. The plague cycles of 1430 and 1460 were two such outbreaks: they were the worst to follow the Black Death. Both lasted for about four and a half months. In Cairo, the plague of 1430 claimed about 90,000 lives and the 1460 outbreak some 70,000 lives.[3]

---

2 Dols provides a fairly detailed appendix of the outbreaks that followed the Black Death, to the end of the Mamluk period (1517 CE). He concludes (1977: 223–24) that there were some twenty-eight outbreaks in Egypt in the interval 1349–1517 CE, with cycles of recurrence every five and a half years.

3 Quantitative primary evidence (including figures for daily death tolls) supports this conclusion. For the 1430 plague, see al-Maqrīzī (*al-Sulūk*, 4: 822–26), Ibn Ḥajar

What we know about these plague outbreaks—qualitatively and quantitatively—are details provided by eye-witness observers, like Ibn Ḥajar al-ʿAsqalānī and al-Maqrīzī for the 1430 plague and Ibn Taghrībirdī for the 1460 plague. These three men (among other witnesses) were members of the elite class of urban scholars. What they record are the number of plague deaths per day (and sometimes the totals for certain periods of time). These numbers were conveyed to them by high-ranking members of the Circassian (Mamluk) military regime and its civilian bureaucracy. The bureaucrats themselves obtained the figures for the number of plague deaths per day by one of two methods. The first was derived from an account of deaths listed by name and registered by the Department of Inheritances. But this was only a partial record, perhaps one-third of all urban deaths, because the vast number of anonymous and propertyless poor were not counted. The second method was more comprehensive and consisted of counting corpses that were brought to a *muṣallā*, which might best be translated as "prayer site" or "oratory."

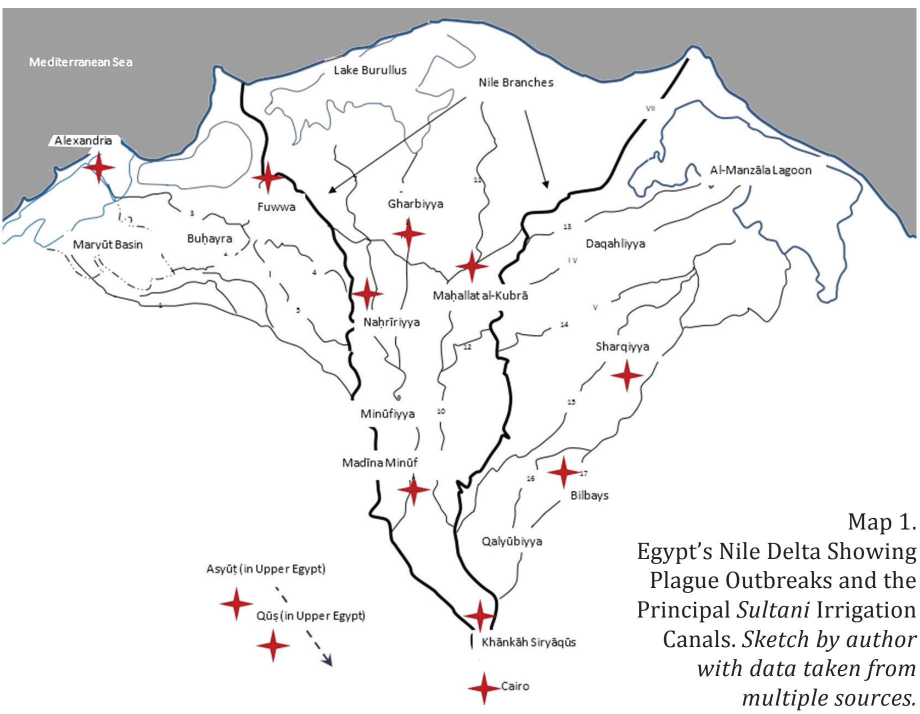
The *muṣallā* was an open place with a more limited ceremonial scope than a mosque. It was often located at a city's gates, with a designated wall for the prayer niche (*mihrab*). The *muṣallā* most often referenced in the course of these two outbreaks was that of the Bab al-Nasr at the northern end of Fatimid Cairo. Here, bodies were brought for the brief "funeral prayer" (*janāza*) that preceded actual burial. In 1430, however, these funeral prayers were performed with great haste over long lines of bodies. This mass blessing was then followed, in 1430, by burial en masse, with graves dug out for forty or more corpses at a time (Ibn Taghrībirdī, *Ḥawādith*, 14: 341). From these *muṣallā*, of which Cairo had about fourteen in 1430 and seventeen in 1460, the total number of deaths per day were recorded by civilian bureaucrats—sometimes under the direction of leaders (*amirs*) of the regime. These tallies were apparently detailed and conducted with as many as three independent witnesses. Sometimes rounded and sometimes not, the numbers present a complex picture of different urban sectors in which there were mosques, markets, and gates that served as *muṣallā*.

al-ʿAsqalānī (*Inbāʾ*, 9: 200), Ibn Iyās (*Badāʾiʿ*, 2: 113), and Ibn Taghrībirdī (*Ḥawādith*, 14: 339–43). The primary sources for the 1460 plague are Ibn Taghrībirdī (*Ḥawādith*, 16: 130–47; see the translation by Popper (1954–63, 4: 90–100). See also Ibn Iyās (*Badāʾiʿ*, 2: 357). On the 1430 plague, see also Dols (1981: 404–11), who had clearly intended to study the 1460 plague as well (1981: 409).

Analyzing the Data for Rural Plague Mortality

Thanks to these contemporary records, urban death tolls (numbers of deaths per day) from different sources can be compared with one another, and the resulting ratios indicate the data's probable validity. Once a confirmable ratio is established, one can calculate total deaths per day by extrapolating from a single data point (such as a datum from one of the *muṣallā*). From these ratios, final death counts can then be posited and graphed, to represent the number of deaths per day over time.

The graphs for rural mortality from plague outbreaks (**Graphs 1–3**, on pp. 134–5, below) are based on this method of calculation. However, it should be noted that compiling rural depopulation statistics presents more of a challenge. The same sources available for Cairo can also be mined for data on rural plague outbreaks in 1430 and 1460, as well as for one in 1403–04 and another in 1407 (al-Maqrīzī, *al-Sulūk*, 3: 1126 and 4: 43). But the mortality figures that we have for towns and villages outside of Cairo are much less systematic, so we must assess the scale of rural depopulation by adapting and applying the plague curves determined for Cairo. Moreover, we do not know precisely how these rural figures were compiled, but it seems logical that the *muṣallā* funeral rite (and associated body count), as a generalized Islamic practice, worked in roughly the same manner in a village as in a city.



Map 1. Egypt's Nile Delta Showing Plague Outbreaks and the Principal *Sultani* Irrigation Canals. *Sketch by author with data taken from multiple sources.*

Map 1 on the previous page shows the distribution of rural outbreaks that have so far been documented. **Tables 1–3** opposite display data collected from the available sources for the three outbreaks (1403, 1430, and 1460). These figures are rough estimates, as attested by the urban witnesses who recorded them. Hence, the goal here is to convey a sense of *scale and scope*: did hundreds die in large towns like al-Maḥallat al-Kubrā (below)—or was the total mortality in the thousands—or even tens of thousands?

For estimating mortality in these rural locations, Cairo's peak death rates for 1430 and 1460 were scaled down to the two death rates that we have for al-Maḥallat al-Kubrā in 1460 (**Table 3**: 250 per day in February and 300 per day in March): see **Graph 1**. These two curves, which align closely with that of the scaled-down curve for Cairo, can then be averaged and combined into one curve: see **Graph 2**.

Summing up the interpolated areas suggested by this amalgamated curve yields an estimated total number of deaths: approximately 10,000 for the plague outbreak of 1460 in al-Maḥallat al-Kubrā alone. This total mortality can then be tested against the total deaths of the 1430 outbreak in the same locale, for which we have a figure of some 5,000 deaths by January of 1430, some sixty days into the epidemic (Table 3). The sixty-day mark in the 1460 graph above (Graph 2) reads as 4,000 total deaths. The fact that the two figures are comparable suggests that the scale is correct—even if the figures themselves are rounded estimates.

We also have estimated death tolls for the Nile Delta town of Minūf al-ʻUlyā (see Madīna Minūf on Map 1, above) in 1407 CE: a peak death rate of 140 per day and a total death count of 4,400. The same method of adapting the Cairo plague curve (see **Graph 3**), takes a peak death rate of 140 and generates an estimated total deaths of 4,652. The closeness of the estimated total deaths (4,652) and the reputed actual total deaths (4,400) could be a coincidence, but it more likely suggests, again, that the *scale* of the toll reported in our sources is correct—and that for Minuf al-ʻUlya, a total mortality between 4,000 and 5,000 for this epidemic is a realistic estimate.

In sum, Minūf al-ʻUlya was subjected to a series of major outbreaks in 1403, 1407, 1430, and 1460, each claiming several thousand lives. If this method of estimating rural depopulation is effective, then some other towns and villages—like al-Naḥririyya and al-Maḥallat al-Kubrā—must have suffered a similar fate. Prior to this unfolding catastrophe, populations for these provincial centers were likely in the range of 20,000 to 40,000. Al-Qalqashandī describes Minūf al-ʻUlyā as "medium" (*mutawassiṭa*) and al-Maḥallat al-Kubrā as "large" (*ʻaẓīma*). The loss of 5,000 to 10,000 inhabitants in successive blows suggests depopulation

Table 1. Plague Outbreak of 1403

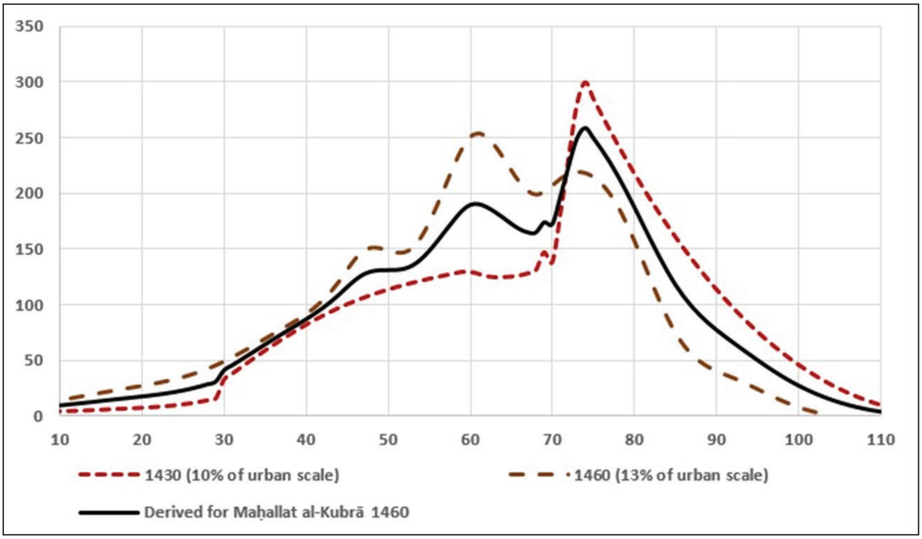
Locale	Daily rate of plague deaths	Sum of plague deaths to date	Month	Sources
Qūṣ		17,000		al-Maqrīzī (*al-Sulūk*, 3: 1126) for 806/1403
Asyūṭ		11,000		al-Maqrīzī (*al-Sulūk*, 3: 1126) for 806/1403

Table 2. Plague Outbreak of 1430

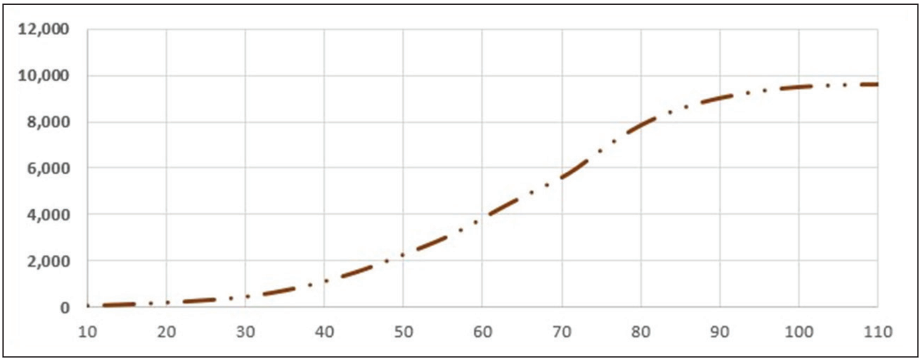
Locale	Daily rate of plague deaths	Sum of plague deaths to date	Month	Sources
Delta (Damanhur, Nahririyya)			December 1429	al-Maqrīzī (*al-Sulūk*, 4: 821)
Maḥallat al-Kubrā		5000	January 1430	Ibn Taghrībirdī (*al-Nujūm*, 14: 337–39); al-Maqrīzī (*al-Sulūk*, 4: 821)
Alexandria	100		February 1430	al-Maqrīzī (*al-Sulūk*, 4: 824); Ibn Taghrībirdī (*al-Nujūm*, 14: 338)
Naḥrīriyya		9000	February 1430	Ibn Taghrībirdī (*al-Nujūm*, 14: 338)
Minufiyya, Qalyubiyya	600		March 1430	al-Maqrīzī (*al-Sulūk*, 4: 825)
Fuwwa, Bilbays			March 1430	al-Maqrīzī (*al-Sulūk*, 4: 827)
Siryaqus	200		March 1430	Ibn Iyas (*Badā'i'*, 2: 138)
Upper Egypt			April 1430	al-Maqrīzī (*al-Sulūk* 4: 829); Popper (1954–63, 4: 93)

Table 3. Plague Outbreak of 1460

Locale	Daily rate of plague deaths	Sum of plague deaths to date	Month	Sources
Sharyqiyya, Gharbiyya			January	Ibn Iyās (*Badā'i'*, 2: 357); Ibn Taghrībirdī (*al-Nujūm*, 16: 139); Popper (1954–63, 4: 93)
Maḥallat al- Kubrā	250		February	Ibn Taghrībirdī (*al-Nujūm,* 16: 140); Popper (1954–63, 4: 93)
Siryaqus	400		March	Ibn Taghrībirdī (*al-Nujūm,* 16: 140); Popper (1954–63, 4: 93)
Maḥallat al-Kubrā	300		March	Ibn Taghrībirdī (*al-Nujūm,* 16: 140); Popper (1954–63, 4: 93)
Madinat Minuf	200		March	Ibn Taghrībirdī (*al-Nujūm,* 16: 140); Popper (1954–63, 4: 93)



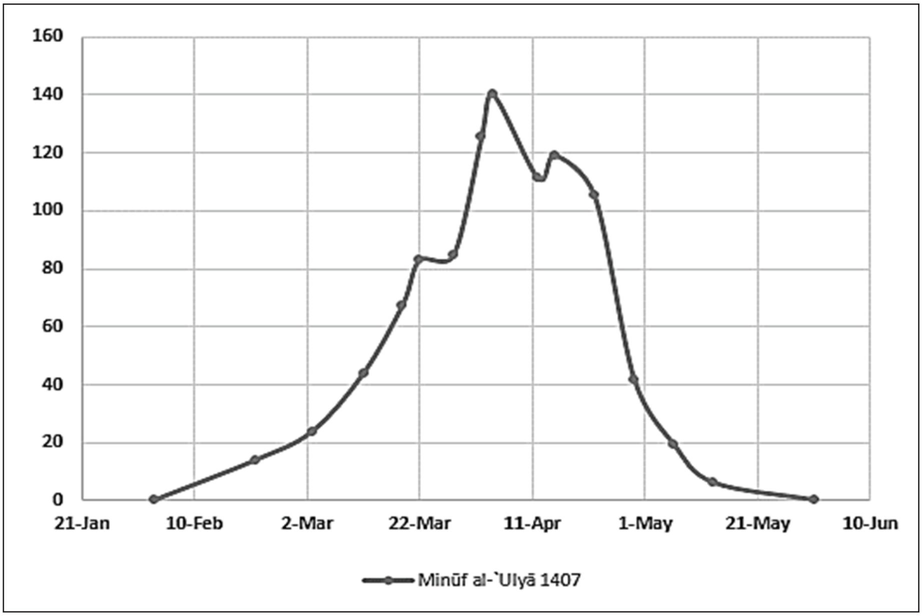
Graph 1. Al-Maḥallat al-Kubrā in 1460 CE: Graph of Plague Deaths over Time as Measured against a Scaled Curve for Cairo



Graph 2. Al-Maḥallat al-Kubrā in 1460 CE: Graph of Rising Death Toll over Time

substantially higher than the one-third estimated by Dols (1977) for Egypt as a whole. The Egyptian historian ʻImād Abū Ghāzī (2000: 65–66), who closely examined rural Egypt via archival documents, suggests that rural Egypt lost more than 40% of its population from 1347 to 1517.

The numbers derived above suggest that Abū Ghāzī's estimate is realistic. Geography argues for it as well: the layout of Egypt's rural areas suggests that it facilitated the spread of plague. Egypt's Nile Valley is a thin strip of arable land, bounded by desert, hugging the Nile River at all points, while Egypt's Delta is crisscrossed with canals and inland waterways that were used for transporting grain on small ships. These spatial



Graph 3. Minuf ʻUlyā in 1407 CE: Graph of Estimated Plague Deaths over Time (as Measured against Cairo Curve)

configurations are ideal for the dissemination of plague-bearing rats and fleas. The annual Nile flood would then have abetted plague mortality by drowning the fields surrounding the villages, forcing rats to seek shelter in human habitations located on higher ground (Conrad 1981). The fact that plague outbreaks continued to strike Egypt with substantial force well into to the nineteenth century may itself be largely attributable to geography (Mikhail 2011: 214–21).

The Irrigation System and the Rural Economy

If rural depopulation was severe, what did it spell out for Egypt's economy? This is where the subject of irrigation plays a major role: to study Egypt's medieval irrigation system is, essentially, to study the economy of preindustrial Egypt. No other aspect or foundation of Egyptian economic activity had a larger impact on its overall economic output.

A few words on the system itself and how it functioned are in order here. Medieval Egypt's irrigation system relied on the spring monsoon over the western Indian Ocean: the monsoon, which fell on the highlands of Ethiopia in June, caused the Nile to flood in the early autumn. As the Nile rose some seven meters up from its low-water level, floodwater was channeled to flood canals (called variously: *khalīj*, *tura*, and *baḥr*) that

Map 2. Flood Canals in Upper Egypt, *c*. 1800 (Nile River at Right, Baḥr Yūsuf at Left)[4]

led water from the Nile River and collected it in enormous basins (Arabic: *ḥawḍ* or *aḥwād*) (**see Map 2**).

The walls containing the water in these basins were enormous dikes (Arabic: *jisr* or *jusūr*), and they held the water in the basin, allowing it to soak into the soil over a period of about a month and a half. Alluvial sediment that washed down from the Ethiopian highlands with the floodwater also settled into the soil, which accounted for Egypt's rich agricultural fertility.[5] When this period of soaking the soil was complete, the remain-

4 Map by M. Schouani, printed in Pierre Jacotin's *Déscription de l'Égypte* (1826); reproduced by kind permission of the David Rumsey Map Collection, no. 3964022.

5 The British colonial hydraulic engineer William Willcocks (1913, 1: 302) analyzed the floodwater's sediment and determined that it contained nitrogen, phosphoric acid, and other nutrients. There were 1.5 kilograms of suspended alluvial matter per cubic meter of floodwater and two-thirds of this came out of solution and was deposited, one millimeter a year, as a layer on Egypt's soil. The deposition of alluvium, ing floodwater was allowed to flow back into the Nile and sowing of seed for the winter crop would commence. So Egyptian agriculture was fundamentally dependent upon its irrigation system—and damage to the irrigation system meant severe damage to Egypt's agrarian sector.

Canals themselves were classified as either perennial canals (*ṣayfī*) or flood canals (*nīlī*). The former were deep enough, and/or had gated weirs, that they were able to provide water year-round, while the latter were only filled during the flood season. These irrigation components, the canals, the dikes, the dams, and the weirs, were controlled by and maintained by the provincial *walī* (governor) and his *mubāshirūn* (roughly, staff or bureaucrats) in the respective provincial capital. From there the governor and his staff acted as authority and liaison for the irrigation system. In their interactions with village elders (*shaykh*, *mashāyīkh*) and village experts (among them the *khawlī*), the provincial authority played a role as both coordinator and coercer.

While much of the agricultural work in medieval Egypt was comparatively light, this was not so for the irrigation system. Enormous labor was required to keep the system going. The village irrigation system itself demanded a heavy toll of labor, but so did the large-scale sultani system that connected the villages to one another—and to the Nile.

During the Mamluk period, Egypt's irrigation system fell into two neat categories. The first of these, the *baladi* system, was the local, village-level system. The village community was supposed to take care of it, without the help of any broader (communal) or higher (coercive) authority, even if the irrigation bureaucracy still played a prominent role in that process. The *sultani* system, by contrast, was everything the *baladi* system was not: it was outside the boundary of the village; it was a non-local system; it was a regional system; it was controlled from a remote center; it linked larger parts of the system together; it linked one part of the *baladi* system to other parts of the *baladi* system; and it connected the *baladi* system, at most points, to the Nile River.

---

dating some 10,000 years back to the last Ice Age, formed a layer roughly ten meters thick in Egypt's Nile Delta. See also Beaumont (1993: 25–29), Ward (1993: 229 and 231), Bowman and Rogan, (1999: 2), Stanley and Warne (1998: 797–804), and Barois (2010: 25). The rich muddy water, the "red water," was highly prized by Egyptian farmers. The scholarly elite of Mamluk Egypt were well aware of the cause of the flood, the source of the alluvial matter, and its properties. Ibn Iyās, writing at the end of the fifteenth century, discusses the crucial difference between the barren prospects of spring water and the enriching quality of the Nile mud. His testimony is one of many in a long tradition of Islamic natural philosophers who examined the various aspects of Egypt's Nile flood (*Nuzhat*: 101–04, 108–12).

The numbers of irrigation laborers that were needed to maintain the *sultani* system, according to three different fifteenth-century authors, are 50,000 for Upper Egypt and 70,000 for Lower Egypt (al-Suyūṭī, *Ḥusn*, 2: 320; al-Maqrīzī, *Khiṭaṭ*, 1: 60; Ibn Iyās, *Nuzhat*: 137). There are also references to the total cost of irrigation maintenance, estimated at 25% of the annual revenue income of the non-hereditary *iqṭā'* landholdings, which would add up to several million gold dinars. It is not clear, however, how the expenditures were supposed to break down. If one takes labor-to-population ratios as a guide, 120,000 irrigation laborers out of a rural population in the millions—where the ratio of labor to total population was in all likelihood on the order of 70%—would seem a rather paltry workforce for a country with such a large and rich arable terrain. However, this figure of 120,000 clearly applied only to the larger-scale interconnecting *sultani* system, and not to the thousands of village systems that fed into the sultani system.[6]

As it turns out, these numbers are quite realistic. If we compare them to nineteenth-century statistics, they match quite closely (see **Table 4**), which means that contemporary reporters were probably talking to someone close to the source, in a *diwan* of the central regime, who understood the system well. For example, after the British occupation of Egypt in 1882, the colonial irrigation engineer William Willcocks (1913, 2: 815) reported that some 400 adult males per village, that is all males between fifteen and fifty years of age, were liable for seasonal corvée work. Willcocks's estimate may have been on the high side; the real figure might have been less than 350, given a likely adult male labor pool (aged fifteen to fifty) consisting of perhaps 25% to 30% of a total village population hovering between 1000 and 1500.

What was the exact nature of this labor, and why did it carry a heavy toll? It seems clear from both modern and medieval sources that the bulk of the work was composed of the annual "reconstruction" of the system in the spring, starting in the Coptic month of Ṭūba. This annual spring work, which was needed to undo the damage wreaked by the Nile flood itself, was (in the Mamluk period) directed by the *kāshif al-jusūr* (provincial *sultani* system inspector) of which there was one for each province, rotating in appointment on a year-to-year basis. The provincial governor (*wālī*) also played an important role here, and his mandate often intersected with that of the *kāshif al-jusūr* (Baḥr 1999, 38–52).

6 See al-Qalqashandī (*Subḥ*, 3: 515–16); Ibn Shahīn al-Ẓāhirī (*Zubdat*: 129); and al-Maqrīzī (*Khiṭaṭ*, 1: 101). See also Cooper (1973: 77), Tsugitaka (1977: 183–84), and Nāṣir (2003: 172, 177).

Table 4. Fifteenth-Century Data on Number of Workers Compared to Nineteenth-Century Data

Year	Laborers	Days Labor	Earthwork (m^3)	Source
1400s	120,000			al-Suyūṭī (*Ḥusn*, 2: 320; *Khiṭaṭ*, 1: 60); Ibn Iyās (*Nuzhat*: 137)
1879	120,000	152	29,000,000	Barois (2010: 68)
	165,000	100		Willcocks (1913, 2: 815)
	125,000	100		Willcocks (1913, 2: 815)
	95,093	100		Willcocks (1913, 2: 815)
1884	125,000	150	29,000,000	Willcocks (1913, 2: 815)
1885	91,000	117	21,000,000	Barois (2010: 69)

There were two principal tasks that took up the lion's share of the spring labor requirements: dredging canals and rebuilding dikes.[7] The dredging of canals meant, for the larger canals, the use of a kind of shoveling device called a *jarrāfa*, which was a large box-like scraper for the bottoms of canals, triangular and measuring eighty centimeters to the side. One or two men would sit on this box to weight it down and dig into the accumulated silt, and when full it would be emptied at the side of the canal (Ibn Shahīn al-Ẓāhirī, *Zubdat*: 128; see also Shaw 1962: 227–28). The dredging of smaller canals usually involved peasants using shovels, and there was a "shovel levy" (a reference to equipment of various kinds) that seems to have been measured for each individual village (Tsugitaka 1997: 230). There was a levy of oxen as well (Abū Zayd 1987: 62).[8] Dredging the

7 Julien Barois (2010: 37), writing in the nineteenth century, makes it clear that the dikes and canals occupied the time of repair crews about equally. In Upper Egypt, he counted 3,550,000 cubic meters of earthwork on the dikes and 4,650,000 in the canals; in all, 8,200,000 cubic meters. He also provided an estimate of the volume of earthwork per hectare for dikes (5.5 cubic meters) and canals (8.7 cubic meters), for a total of 14.30 cubic meters of earthwork per hectare.

8 The shovel levy was assigned in units called *qiṭa'*, perhaps one apparatus per *qiṭa'*, but I suspect it came to have some other standardized meaning that was becoming disassociated with the actual equipment, and may eventually have referred to money payments—or levies of manpower in corvée. See "Rural Society in Medieval Islam," a website maintained by the College of Queen Mary, University of London: <http://www2.history.qmul.ac.uk/ruralsocietyislam/index.html> [accessed October 11, 2014]. It includes a very useful quantitative tool which documents al-Nābulusī's financial information for the Fayyum in the thirteenth century, and the spreadsheet of "Demographic Information" includes the shovel levy, which researchers Rappaport and Shahar suggest using as a relative indicator of population. The levies, in number siltation buildup in the irrigation supply (*sawq*) and drainage (*maṣraf*) canals, whether they were flood canals (*nīlī*) or perennial canals (*ṣayfī*), took up a huge amount of time and heavy labor. Rates of siltation varied widely, and were often anywhere between 0.5 to 1.5 meters per year (Willcocks 1913, 1: 320). Considering that there were probably well over a hundred *sultani* canals for Lower Egypt, and at least half as many for Upper Egypt, it is easy to see how the dredging of all of this silt made for a very heavy manpower requirement (Willcocks 1913, 1: 329).[9] The second task, equally daunting, was to repair the dikes (*jusūr*) that had been cut/broken (*qaṭa'*) to let water in and out in the flood season. This process, the *shāqq*, involved rebuilding the dikes, usually with a material known as *labsh* (approximately, a mixture of mud and straw) (Abū Zayd 1987: 64). The places where cuts and breaches in the dikes had been made and then mended were known as *quṭū'* and formed irregular joints that gave these dikes a zig-zag pattern. The dikes, like the canals, amounted to a very substantial volume of earthwork, and some of them could be as much as 20 kilometers in length (see **Table 5**).

These tasks ate up a lot of man-days (irrigation laborers were all male). One medieval source estimates that the shoring up of dike breaches (*maqāṭi*: made to let water into the basins)—and presumably repairs to flood damage elsewhere along the dike—required the labor of about a hundred men and fifty oxen with *jarārīf* (shovels) and *miḥārīth* (plows) for five months (Baḥr 1999: 50–51). Medieval records also indicate that the number of *sultani* dikes in the Delta numbered in the several hundreds. From these sources, we can estimate something on the order of 350 *sultani* dikes in the Delta. This (350 × 100 laborers) would account

---

of *qiṭa'*, vary from a low of .083 for one village to a high of 9 for a particularly large village. The average for the Fayyum is 1.16 and the sum total 104.66. Al-Nābulusī also discusses an instance where a hundred *jarrāfa* (*qiṭa'*) were levied from the Fayyum as a whole, with ninety-five being the number actually collected. Other totals are found in numerous sources. One example is two hundred *qiṭa'* levied for the construction of the Jisr Shībīn in Qalyūbiyya in the early 1300s, a job that cost about 60,000 gold dinars, employed 12,000 in labor, and lasted three months. So 1 *qiṭa'* of *jarrāfa* was presumably a fairly substantial amount by itself. For detail on the Jisr Shībīn, see al-Maqrīzī (*al-Sulūk*, 2: 466–67).

9 Even with half of Upper Egypt's arable given over to perennial irrigation, there were still forty-five major flood canals in use, and presumably all of these would have been classified as *sultani* in the medieval period, as they each seemed to have served more than one village. Given that, one should double the figure to forty-two for Upper Egypt. And then, given that Lower Egypt had a much higher density of irrigation components, it is easy to see why something well in excess of a hundred would be reasonable.

Table 5. Dike Lengths and Volume of Earthwork[10]

Locale	Name of Dike	Length (m)	Total Volume of Earthwork (m^3)
Al-Minyā	Ṭahnashāwī	23,450	592,196
Mallawi	Kudyah	14,000	1,376,000
Asyūṭ	Donhea	8750	175,000
Manfalūt	Banī Kalb	17,500	551,638
Manfalūt	Maharriq	17,500	551,638
Girgā	Manshīyah	15,750	1,935,000
Upper Egypt	Annual	183,390	11,999,208

for half of the 70,000 men required for work in the Delta, with canal-dredging probably requiring another 35,000 men. Again, these estimates are not intended to be exact, but rather to approximate the scale and scope of manpower. The nineteenth-century data provides a very important cross-reference, with figures ranging from 95,000 to 150,000 men at work for 100 to 150 days, suggesting the validity of these medieval numbers. Egyptian flood dikes were enormous, and the data on dikes from the 1800s (**Table 5**) give a good idea of the volume of earthwork that medieval Egyptians accomplished every spring. The figures in the table are a guide to the dimensions of spring reconstruction.

When the manpower capacity, the volume moved per man-day (which averaged about 1 to 1.5 meters cubed), is applied to these figures, we see again that the total labor requirements were imposing and would easily add up to the 120,000 estimated by the medieval sources. Medieval accounts also match these dike figures in terms of length, total volume of earthwork, and man-days employed.

What this means, for our purposes, is that the decay of this labor-intensive system was a very likely result of the scarcity of rural labor caused by plague mortality. There were, moreover, a number of contributing factors that greatly intensified the irrigation system collapse, and these appear to have been maladaptive responses to the economic shock of depopulation. Egypt's military elite played a role here: these elites, essentially synonymous with the urban landholding caste at this time, added to the crisis by forcing rents upward, coercing corvée in the place of wages, redirecting irrigation-system taxes to their own coffers, and in essence looting the rural economy (Borsch 2005: 42–60). These things added to the direct damage of depopulation and irrigation labor scarcity, making for a

10 Sources: Clot-Bey (1840: 473–74) and Rivlin (1961: 285).

poisonous combination of factors whose effects on the irrigation system became quite apparent by the early fifteenth century. Many witnesses of this period testify to these problems.[11] The encyclopedist al-Qalqashandī, writing in the early fifteenth century, notes that "in our times, the maintenance of the *baladi* (local village) systems are being neglected, and upkeep of the *sultani* (interconnecting) system has been limited to the most trivial repairs that have little impact on production." Furthermore, he continues, "the level of the Nile has, at many times, been as high as 19 or even 20 cubits, and despite this, the irrigation system does not provide adequate floodwater and agrarian production is weakened" (*Subḥ*, 3: 516).

Al-Qalqashandī's intention, in emphasizing the height of the annual Nile flood, is quite clear, and his meaning is echoed by several other contemporary chroniclers. The subject of flood heights was a source of endless anxiety for Egyptians whose prosperity rose and fell with the outcomes of the annual flood. The ideal flood level at this time was between 17 and 18 cubits (a cubit was a linear measure of .462 meters) on the upper end of the scale on the Nilometer: a stone pillar used to measure the Nile flood. The level celebrated by old tradition was 16 cubits, at which mark the flood was said to have reached fulfillment—or completion (*wafā'*)—at a point in the flood season, usually in August, when there was a public ceremony and the main canal (Khalīj Amīr al-Mu'minīn) was opened.[12] Above that, 17 to 18 cubits was regarded as a sufficient level for providing floodwater to the majority of the agricultural areas, whereas a level lower than 17 cubits might risk leaving areas under-watered and dry.[13] On the other hand, a level higher than 18 cubits, somewhere in the range of 19 to 20 cubits, was considered potentially dangerous: an overly high flood could wreak a lot of damage—to the irrigation system, and to villages and homes; an over-inundation could also drown a significant portion of the cultivable region (Ibn Iyās, *Nuzhat al-umam*, 88–89; al-Maqrīzī, *Khiṭaṭ*, 1: 60; Barois 2010: 24).

Clearly, then, al-Qalqashandī's narrative suggests that these quantitative rules have been changed: that a level of 19 to 20 cubits, far from

---

11 See al-Maqrīzī (*al-Sulūk*, 4: 564, 618, 646, 678, 709–10, 750–53, 806–09, 834, 863, 874, 903–04, 931, 950); Ibn Iyās (*Nuzhat*, 182); Ibn Taghrībirdī (*Ḥawādith*, 4:573); Ibn Iyās (*Badā'i'*, 5: 114–15); Suyuti (Husn, 2: 302). See also Petry (1994: 114–15 and 124–25).

12 Al-Maqrīzī (Khiṭaṭ, 1: 55); see also Abū Zayd (1987: 18) and Nāṣir (2003: 173). Traditionally, the flood was said to begin its rise on the night of the Feast of Saint Michael ('Īd Mīkā'īl), on the twelfth day of the Coptic Month of Ba'una (June 20).

13 Specifically, 12 to 13 cubits was considered dangerously low (Said 1993: 98).

providing too much water, was in fact not providing enough; despite high flood levels, much of the agricultural land was going dry. The Nile itself was not to blame, nor even the sediment that built up on the river bed, sediment that caused its natural crest level to rise every year. It was, in fact, the irrigation system itself that was causing the problem. When canals became silted up and blocked, floodwater was prevented from reaching the irrigation basins, even when the Nile level was far more than adequate (al-Maqrīzī, *al-Sulūk*, 4: 903). And when dams and weirs were in disrepair, floodwater was no longer being provided according to schedule. And of greatest importance was the role of the dikes. The Nile reached its peak in the Coptic month of Tūt (approximately September). When the flood was at or near peak, water was led into the flood basins.[14] The floodwater was then held in these enormous basins for forty to fifty days.[15] Any shortening of this time period would mean that the basins were insufficiently full for watering the winter crop. When the Nile began to descend in the Coptic month of Bābih (roughly October, in the fifteenth century), it was essential that the dikes held the water in as the flood went down (Willcocks 1913, 1: 307, 311). Any failure in the dike system (cuts in the dikes, holes in the dikes, breaches in the dikes) meant a failure to check this flow.[16] It meant that water would leak from the system before the proper time, and therefore meant a failure to irrigate the flood basins and a failure to provide adequate watering for the critically important winter crop.[17]

14 The schedule called for specific, targeted openings at different times, such as at Nawrūz (New Year's Day), on the first day of the Coptic month of Tūt (corresponding to September 12) and on the ʻĪd al-Ṣalīb (the Festival of the Cross) on the seventeenth day of the Coptic month of Tūt (corresponding to September 29). See Abū Zayd (1993: 18–19) and Willcocks (1913, 1: 304).

15 The reported average time is forty-five days (Willcocks 1913, 1: 301). Other durations are also given (Barois, 2010: 25).

16 The management of the *sultani* system included provisions for watchmen who were assigned to monitor the canals and dikes carefully, to watch for any breaks in the dikes or problems with canals. See the roles of the *khufarā'* and *ḥurrās* in Ibn Mammātī (*Qawānīn*: 229). See also Cooper (1993: 229), Tsugitaka (1977: 333), and Abū Zayd, (1983: 13).

17 When flood was to be let into a confined area, the dikes were broken open. The places where they were broken open were called *quṭū'*. From the same Arabic root, we get the word for open ruptures in the dikes (*maqāṭi'*) that were repaired in the early spring. In the Coptic months of Ṭubih (January 10 to February 8) and Amshīr (February 9 to March 9), dikes that had been broken open in the early autumn, to let water in, were sealed up again using harrows (*jarārīf*) and mud mixed with straw (*labsh*). See Ibn Mammātī (*Qawānīn*: 244–45); see also Abu Zayd (1987: 17, 64–65) and Cooper (1973: 103).

In this instance, al-Qalqashandī indicates that this delicate process was not being observed. Damage to the system, failure to maintain and repair dams, dikes, and canals, was causing it to malfunction. The failure of the canals to supply the water, along with the failure of the dikes to hold the water in, was causing the basins to go dry. Hence, damage to the system was causing a very high flood level (19 to 20 cubits) to look like a very low flood level, leaving much of the agricultural land dry.[18] So in this sense, damage to the irrigation structure was not only wreaking havoc with the operation of the system, but also with the level indicators that allowed for proper control of the system.[19] Managers of the system, depending upon a traditional corpus of knowledge, thus might anticipate flood damage and respond accordingly, when in actual fact, the level of the flood was barely adequate. It is clear from this account that serious harm had come to the irrigation system.

By the early fifteenth century, irrigation system decay was apparent to all observers. Plague depopulation, coming in cycles for the last half-century, had been taking its toll, denuding the rural labor force of its numbers. The notes taken by Ibn Iyās in the late fifteenth century, coupled with those of other witnesses, suggest that the irrigation system in Upper Egypt had been gravely impaired by that time, and that the Lower Egyptian system had been affected in a similar manner (Borsch 2000: 137–39). Furthermore, the changes in the indicators—this confusion by which flood levels could no longer be read—is also palpable in the sources for this time. To know that serious maintenance was needed was one thing, but to realize that a traditional timetable, developed over centuries, was malfunctioning, was another thing altogether (Nāṣir 2000: 170). It was recognized that the time-tested ways of controlling the flood were now failing. There was also a sense that the traditional system of flood prediction had gone awry. During the flood of 1468, Nile officials were reputedly stunned when their predictions based on patterns of alluvial deposit failed for the first time since the Islamic conquest of Egypt in 640

---

18 If, for whatever reason, flood levels were too low, the impact of abandoned land could affect the afflicted rural areas for years. ‘Abd al-Laṭīf al-Baghdādī’ furnishes us with an account of the two years that followed a disastrously low flood in the year 1200, when the flood waters, “receded without the country having been sufficiently watered, and before the convenient time, because there was no one to arrest the waters and keep them on the land” (al-Baghdādī, *Kitāb al-’ifāda*: 253–54).

19 Openings and closings of the canals and dikes followed a very complicated and precise schedule set down in the *qawānīn al-riyy* (the rules, also called “logs” or “registers” for irrigation). See Ibn Mammātī (*Qawānīn*: 205–32) and al-Maqrīzī (*al-Sulūk,* 1: 61, 171). See also Cooper (1973: 397) and Thayer (1993: 123).

CE. Other events, such as the highly unusual crest of the river in 1479—arriving half a month early on the twenty-ninth day of the Coptic month, Abīb (August 6)—added to the general level of anxiety (Petry 1994: 123). For the year 1508, we are told that the flood surged "fifty fingers" (1.125 meters)[20] in a single day—and this apparently had happened only twice since the Arab conquest (Petry 1994: 123).

The magnitude of the crisis and the uncertainty it was causing thus loomed very large in the eyes of these contemporaries. It seemed to them that the Nile, as well as the irrigation system, could no longer be trusted. But as bad as the psychological impact may have been, the physical effects were of course more immediate—and bone-dry flood basins were not the only concern here, as level indicators went awry. It seems clear that episodes of destructive flooding made at least as much of an impression as did episodes of drought, involving, as these episodes did, the destruction of dikes that were caught in the flood's wake. One record from the year 1432 CE notes that "dikes were ruined and many lands drowned, and water rushed into many of the villages before the proper time (for filling the basins). Summer crops such as cucumbers, sesame, and indigo were all ruined—to the loss of thousands of dīnārs" (al-Maqrīzī, *al-Sulūk*, 4: 874). Just as broken dikes could allow floodwater to leak from basins before the watering was done, so too could they fail to hold back high levels of water, as they were designed to do. Hence, just as a high crest could still leave many lands dry, a normal crest could swamp low-lying villages with a torrent of water.[21] More distressing were times when these two curses were compounded, and a flood too high was also a flood too low. In the same year that a destructive flood was sweeping through and ruining villages in many areas, the opposite was occurring in other parts of the country: areas were being left dry by the absence of this same flood. Floodwater was surging in places where dikes failed to protect low-lying lands, and pouring out of areas where dikes were failing to retain water (al-Maqrīzī, *al-Sulūk*, 4: 874). The combination of the twin evils added to the sense of confusion and dismay.[22]

---

20 One finger on the Nilometer was 2.25 centimeters or 1/24th of a .541 cubit (*dhirā'*) (Allouche 1994: 88).

21 Ibn Iyās (*Nuzhat*, 88–89), al-'Asqalānī (*Taysīr*: 171), al-Qalqashandī (*Subḥ*, 3: 515), and al-Maqrīzī (*al-Sulūk*, 4: 806–09, 874). See also Barois (2010: 36), Abū Zayd (1987: 61), and Nāṣir (2003: 171–72).

22 Under these conditions, it seems likely that there were problems with salinity as well. The land category of *sibākh* was designated for areas that could not be cultivated due to high salt content: see Ibn Mammātī (*Qawānīn*: 204); al-Maqrīzī (*al-Sulūk*, 2:

Most witnesses seem to have been aware that these twin disasters of drowning and parching were connected to the underlying irrigation system decay. For the years 1432 and 1435, al-Maqrīzī (*al-Sulūk*, 4: 874) makes a clear connection between these problems and system damage and notes that the decay of the system was compounding and multiplying the natural vulnerability of Egypt's inundation agriculture. Chronicles of the fifteenth century are, in fact, replete with very specific examples of what went wrong with the system as it fell apart (Borsch 2005: 44). And system failure, when it occurred, could happen on a very large scale. Problems with the larger, interconnecting (*sultani*) system could have a profound effect not only on downstream villages, but on the local, village (*baladi*) systems, too. In the year 1428, for example, there was an enormous toll of damage. Disaster struck the villages of Zifta, Shubra, and their outlying areas and was blamed upon the neglect of the irrigation system maintenance. In 1477, the chronicler al-Ṣayrafī tells how major parts of Cairo were badly damaged by floods because of dike failure in the area (cited by Nāṣir 2003: 173). Separate reports from Ibn Ḥajar al-ʿAsqalānī and Ibn Iyās inform us that a major disaster occurred when the enormous *sultani* dike of the Baḥr Abī al-Manajjā failed and numerous downstream villages were drowned by floodwater. And violent flood surges, intimidating during times when the system was functioning well, became catastrophic as the system fell apart.[23] Frequently, large sections of the *baladi* system were taken down as parts of the *sultani* system failed. This is hardly surprising, bearing in mind that the *sultani* dikes and canals were just as important for protecting the *baladi* system from water as they were for supplying it. The vulnerability of the *baladi* system meant that

130, 166); see also Tsugitaka (1977: 230) and Cooper (1973: 33, 37). Willcocks (1913, 1: 308) says that "If the distribution is bad […] some basins receive little but sand, others have far more than their share of rich mud, and the greater part have nothing but the finest particles of mud with a large proportion of salts; especially is this the case where white water has stood for any length of time without any perceptible flow."

23 It is important that one visualize the flow dynamics of the system. A flood which might only be 2 meters above the ground can wreak major havoc when a large volume of the water is penned back by a major dike. Julien Barois (2010: 33), observing the system in the nineteenth century, noted that "when one of these dikes becomes broken by the pressure of the water, great havoc may result, because in general the level of the flood much exceeds that of the riparian lands, and especially in certain parts of the Delta the high water reaches normally 2 meters above the soil of the valley." Some *sultani* dikes were of huge proportions. One dike in the suburbs of Cairo was 16 meters high and built to a depth of 32 meters. See Tsugitaka (1977: 229–30). So too would depressions created by ruined canals pen up water, where it could apply stress to already weakened dikes.

Table 6. Estimated Agrarian Production over Time

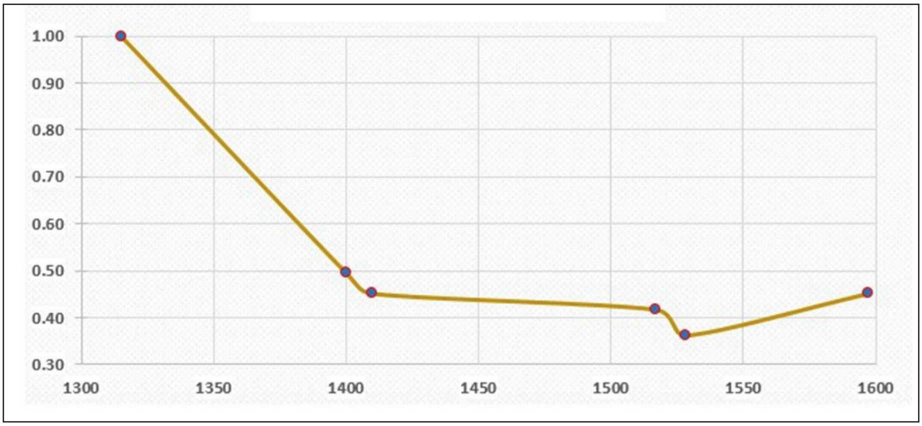
Year (CE)	Agrarian Output (1315 = 1)	Source
1315	1.00	Borsch (2005: 77)
1400	0.50	Extrapolated from treasury figures (Ibin Shahīn, *Zubdat*: 107)
1410	0.45	Mujani (2008: 1113)
1517	0.42	Borsch (2005: 80–88)
1528	0.36	Michel (2002 : 197–251)
1597	0.45	Borsch (2005: 80–88)

sections would go down like dominos, the failure of one set of basin dikes meaning that the entire chain, as many as eight basins in length, would be threatened with collapse (Borsch 2000: 459–60).

Problems appeared at intervals. Calm could prevail for decades only to be suddenly followed by catastrophic and unpredictable crashes of whole segments of the system.[24] This cycle seems to have continued through to the end of the fifteenth century, and it had a number of effects on the wider economy, and not just the rural sector. It was in this context, we can say, that Egypt's irrigation system collapsed via a process of punctuated equilibrium (Borsch 2004: 461). Egypt's fifteenth-century irrigation system seems to have persisted in a state of slow change/slow neglect until sudden and dramatic episodes of regional collapse occurred. Each time the system's functioning was punctuated by an episodic crash, repair costs escalated and the task of restoring the system became significantly more daunting. By the end of the Mamluk period (1517 CE), Egypt's irrigation infrastructure had been largely ruined by the direct and indirect impact of plague depopulation. In addition to the evidence that we have from the fifteenth century chroniclers—and the data for irrigation labor—estimates of total agrarian production (**Table 6** and **Graph 4**) lead to the same conclusion.

Here, data points gleaned from sources composed in the course of the fifteenth century are supplemented by data from the early Ottoman era, which also recorded irrigation system decay. For example, the Ottoman land survey, conducted in 1528, offers data for the northwest Delta province of al-Buḥayra (**Map 3**), which allow us to compare the irrigation system's performance in that year with that of the 1315 land survey con-

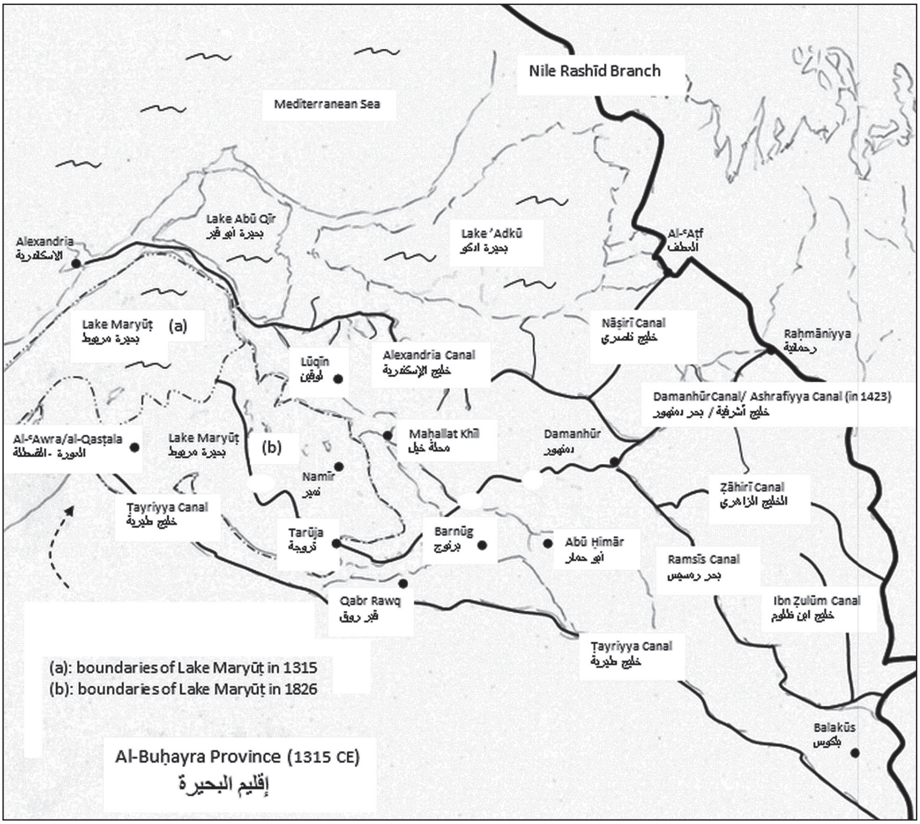
24 Ibn Taghrībirdī (*Ḥawādith*, 4: 67), al-ʻAsādī (*al-Taysīr*: 92–93), and Ibn Iyās (*Badā'i'*, 5: 114–15; *Nuzhat*: 182). See also Borsch (2000: 461).



Graph 4. Estimated Agrarian Output of Egypt (1.0 = Land Survey of 1315 CE)

ducted when the Mamluk Sultanate was at its economic peak. The spatial patterns of decay (villages with little or no output on the downstream ends of the provinces' *sultani* canals) indicate system decay in excess of 60% (Michel 2002). If we look much further ahead, we find a scene of mortality and economic disruption that seems to resemble that of the fifteenth century. The death toll of the plague outbreak in Cairo, in 1791 CE, was one of the worst of the Ottoman period; it is evocative of the terrible 1430 and 1460 outbreaks, with peak mortalities of 1,500 and 2,000 deaths per day (Mikhail 2011: 221–23). Given the analysis above for the fifteenth-century outbreaks, it seems unlikely that these peak mortality rates were exaggerated; total death tolls for Cairo, reported as well over 50,000, are realistic. The city of Alexandria can serve as a special example of demographic catastrophe over this long term, its population dropping from an estimated 100,000 in the Mamluk era to some 6,000 to 8,000 by the early nineteenth century (Le Père 1818: 10; Panzac 1978: 85; Panzac 1987: 86-87).[25]

25 We do not have any reliable population data for the medieval population of Alexandria, but Mamluk-era figures for the number of silk weavers in the city give us a rough sense of the scale of population at this time, and two separate accounts provide estimates that are close to one another. If there were over 10,000 silk weavers in the late thirteenth and early fourteenth centuries (one report lists some 14,000 for 1380, another some 12,000 for 1295) one might guess that a very *minimum* population level might be reasonably close to 100,000, which would assume that a very high percentage of the adult (presumably male) population was engaged in silk weaving. But given the plethora of trades in Alexandria and other cities of the Mamluk Sultanate at this time, it seems unlikely that silk weaving comprised so high a share of the total working (again presumably male) population. 100,000 would be a minimum.



Map 3. The Province of Buḥayra Showing Sultani Canals.
Sketch by author after maps in Jacotin (1828).

An Agenda for Future Studies of Plague's Impact in Egypt and Elsewhere

The case of medieval Egypt calls for further examination of the irrigation system in a long-term perspective that includes the Ottoman period as well as the Mamluk era considered here; study of the early nineteenth century would provide a valuable comparison based on population figures as well as on land survey data. It also goes without saying that the impact of plague in the Middle East as a whole calls for much more attention, especially given its role in shaping the long-term divergence between the economies of this region and that of Europe. Indeed, this article's analysis of Egypt's demographic and economic response to plague outbreaks suggests that other irrigation systems might have been similarly affected. An agenda for future research would therefore include analogous systems like that of Mamluk Syria, Iran's network of underground canals (*qanats*), and the irrigation system of Iraq. Comparisons of irrigation systems could also extend to case studies of plague depopulation and its potential economic impact in South Asia (e.g., Sri Lanka) and East Asia as well. In addition to China's irrigation system, the flood recession economy of Cambodia's Angkor Kingdom is an especially interesting candidate for future research, precisely because Angkor's sophisticated irrigation network fell apart in the fifteenth century: an event suspect in its timing. This collapse has hitherto been attributed to its extreme complexity, but the study of population levels could suggest other causes.[26] Paying attention to changing irrigation economies, more broadly, could therefore help us to trace the impact of plague depopulation in world history.

Egypt's long-term response to plague-induced demographic decline proves that outcomes differed drastically from place to place, contingent upon dependent variables like social structure and environment. But there are other important lessons to be learned from future studies of plague in this area. For example, Egypt has the potential to teach us something new about plague's biology. After all, its experience with plague lasted for a very long time: it was still tormented by the disease in the eighteenth and nineteenth centuries. As Nükhet Varlık observes (2014, in this issue), a truly global approach to the study of this pandemic complicates the neat Eurocentric periodization of plague's history and must be factored into new narratives and future scholarly approaches. So what made Egypt's disease trajectory (and perhaps that of the Middle East as well) so different? My tentative answer would be that Nile flood geography and its influence upon insect and rodent vectors played a substantial role, and I propose this as another agenda item for future research (see Carmichael 2014, in this issue). Furthermore, it is worth considering how Egypt's mass graves, which we suspect were as plentiful there as in Europe, might supply bioarcheological data comparable to that derived from the East Smithfield cemetery of medieval London (see DeWitte 2014, in this issue). Egypt's famous aridity, and the process of desiccation that has yielded so many well-preserved bodies from antiquity, is an important factor here. Consider the multitude of sandy graves amid the two huge cemeteries (the *Qarafatayn*, they were called) ringing the eastern edge of Cairo. We might find a rich if grim treasure trove of evidence in some of these graves, soft tissue residue as well as skeletal remains worthy of careful study.

26 Theories range from war to environment to irrigation system complexity: Moore 1989; James 1995; Higham 2002; Penny et al. 2005; Stone 2006 and 2009; Chandler 2007; Evans et al. 2007; Fletcher et al. 2008; Kummu 2009; Buckley et al. 2010; Diamond 2011.

Bibliography

Medieval Sources

al-ʻAsādī, Muḥammad ibn Muḥammad. *al-Taysīr wa-al-iʻtibār wa-al-taḥrīr wa-al-ikhtibār fīmā yajibu min ḥusn al-tadbīr wa-al-taṣarruf wa-al-ikhtiyār*, ed. ʻAbd al-Qādir Aḥmad Ṭulaymāt (Cairo: Dār al-Fikr al-ʻArabī, 1968)

Badr al-Dīn al-ʻAynī, Maḥmūd*. ʻIqd al-jumān fī tārīkh ahl al-zamān*, ed. Muhammad Muhammad Amīn, 4 vols. (Cairo: al-Hay'ah al-Miṣrīyah al-ʻĀmmah lil-Kitāb, 1987)

al-Baghdādī, ʻAbd al-Laṭīf. *Kitāb al-ʻifādah wa-al-iʻtibār*, ed. and trans. John A. and Ivy E. Videan (London: Allen and Unwin, [1965])

Ibn ʻAbd al-Wahhāb Nuwayrī, Aḥmad. *Nihāyat al-ʻarab fī funūn al-ʻadab*, ed. Saīd ʻAbd al-Fattāḥ ʻĀshūr, 33 vols (Cairo: al-Mu'assaa al-Miṣrīya al-ʻĀmma lil-Ta'līf wa al-Tarjama wa al-Ṭabā'a wa al-Nashr, 1964)

Ibn Ḥajar al-ʻAsqalānī, Aḥmad ibn ʻAlī. *Inbā' al-ghumr bi abnā' al-ʻumr*, ed. Ḥasan Ḥabashī, 9 vols. (Beirut: Dār al-Kutub al-ʻIlmiyya, 1969)

Ibn Iyās. *Badā'iʻ al-zuhūr fi-waqā'iʻ al-duhūr*, ed. Muṣṭstafá Muhammad, 5 vols. (Cairo: al-Hay'ah al-Miṣrīyah al-ʻĀmmah lil-Kitāb, 1982)

Ibn Iyās. *Nuzhat al-umam fī-l-ʻajā'ib wa'l-ḥikam*, ed. Muḥammad Zaynham Muḥammad ʻAzab (Cairo: Maktaba Madbūlī, 1995)

Ibn al-Jīʻān, Yaḥyā ibn al-Maqarr. *Kitāb al-Tuḥfa al-sanīya bi-asmā' al-bilād al-Miṣrīya*, ed. Bernhard Moritz (Cairo: Imprimerie nationale, 1898)

Ibn Mammātī, Al-Asʻad. *Kitāb al-qawānīn al-dawānīn*, ed. A. S. Atiya (Cairo: al-Jamʻīya al-Zirāʻiya al-Malakīya, 1943)

Ibn Shahīn al-Ẓāhirī, Khalīl. *Kitāb zubdat kashif al-mamālik wa-bayān al-ṭuruq wa-al-masālik*, ed. Paul Ravaisse (Paris: Imprimerie nationale, 1894)

Ibn Taghrībirdī, Yūsuf. *Ḥawādith al-duhūr fī madá al-ayyām wa-l-shuhūr*, ed. William Popper, 4 vols. (Berkeley: University of California Publications in Semitic Philology, 1930–42)

Ibn Taghrībirdī, Yusūf. *al-Nujūm al-zāhira fī mulūk Miṣr wa'l-Qāhira*, ed. Fahīm Muhammad Shaltūt and Jamāl al-Dīn Shayyāl, 16 vols. (Cairo: al-Hay'ah al-Miṣrīyah al-ʻĀmmah lil-Kitāb, 1972)

al-Maqrīzī, Aḥmad Ibn ʻAlī. *Kitāb al-mawā ʻiẓ wa-l-i ʻtibār bi-dhikr al-khiṭaṭ wa-l-āthār*, 2 vols. (Cairo: [printer unknown], 1853–54)

al-Maqrīzī, Aḥmad Ibn ʻAlī. *Kitāb al-Sulūk li-Maʻrifat Duwal al-Mulūk*, ed. Muḥammad Muṣṭafā Ziyāda, 12 vols. (Cairo: Lajnat al-Ta'līf wa al-Tarjama wa al-Nashr, 1956–73)

al-Qalqashandī, Aḥmad ibn ʻAlī*. Subḥ al-aʻshā fī sināʻat al-inshā*, ed. Muḥammad Ḥusayn Shams, 15 vols. (Beirut: Dār al-Kutub al-ʻIlmiyya, 1987)

al-Suyūṭī, Khalīl Manṣūr. *Husn al-muḥāḍarah fī tārīkh Miṣr wa-al-Qāhirah*, 2 vols. (Beirut: al-Maktabah al-ʻAṣrīyah, 2009)

Modern Sources and Secondary Scholarship

Abū Ghāzī, ʻImād Badr al-Dīn. 2000. *Taṭawwur al-ḥiyāzah al-zirāʻīyah fī Miṣr: zaman al-Mamālīk al-Zharākisah: dirāsah fī bay ʻamlāk Bayt al-Māl*. al-Haram (Giza: ʻAyn lil-Dirāsāt wa-al-Buhūth al-Insānīyah wa-al-Ijtimāʻīyah)

Abū Zayd, Muhammad Mahmūd ʻAli. 1987. *al-Nīl wa-Miṣr: dirāsah li-athar al-Nīl fī al-ḥayāh al-iqtiṣādīyah wa-al-ijtimāʻīyah fī Miṣr min al-fatḥ al-Islāmī ḥattá muntaṣaf al-qarn al-rābi' al-Hijrī* (Cairo: Dār al-Hidāyah)

Allouche, Adel. 1994. *Mamluk Economics: A Study and Translation of al-Maqrīzī's "Ighāthah"* (Salt Lake City: University of Utah Press)

Ashtor, Eliyahu. 1949. "Prix et salaires à l'époque mamlouke: une étude sur l'état économique de l'Égypte et de la Syrie à la fin du Moyen Âge," *Revue des études islamiques* 17: 49–94

Ashtor, Eliyahu. 1969. *Histoire des prix et des salaries dans l'Orient médiéval* (Paris: S.E.V.P.E.N)

Ashtor, Eliyahu. 1976. *A Social and Economic History of the Near East in the Middle Ages* (Berkeley: University of California Press)

Ashtor, Eliyahu. 1977. "Levantine Sugar Industry in the Later Middle Ages—An Example of Technological Decline," *Israel Oriental Studies* 7: 226–80

Bacharach, Jere. 1971. "Circassian Monetary Policy: Silver," *Numismatic Chronicle* 11: 267–81

Bacharach, Jere. 1976. "Circassian Monetary Policy: Copper," *Journal of the Economic and Social History of the Orient* 19: 32–47

Bacharach, Jere. 1983. "Monetary Movements in Medieval Egypt, 1171–1517," in *Precious Metals in the Later Medieval and Early Modern Worlds*, ed. J. F. Richards, 159–81 (Durham, NC: Carolina Academic Press)

Baḥr, Majdī ʻAbd al-Rashīd. 1999. *al-Qaryah al-Miṣrīyah fī ʻaṣr salāṭīn al-Mamālīk, 648–923 H/1250–1517 M* (Cairo: al-Hay'ah al-Miṣrīyah al-ʻĀmmah lil-Kitāb, Far ʻal-Ṣiḥāfah)

Barois, Julien. 2010. *Irrigation in Egypt*, trans. A. M. Miller (Washington, DC: Government Printing Office)

Bavel, Bas van. 2006. "Rural Wage Labour in the Sixteenth-Century Low Countries: An Assessment of the Importance and Nature of Wage Labour in the Countryside of Holland, Guelders and Flanders," *Continuity and Change* 21: 37–72

Beaumont, P. 1993. "Climate and Hydrology," in *The Agriculture of Egypt*, ed. C. M. Craig, 16–38 (Oxford: Oxford University Press)

Borsch, Stuart. 2000. "Nile Floods and the Irrigation System in Fifteenth-Century Egypt," *Mamluk Studies Review* 4: 131–45

Borsch, Stuart. 2004. "Environment and Population: The Collapse of Large Irrigation Systems Reconsidered," *Comparative Studies in Society and History* 46: 451–68

Borsch, Stuart. 2005. *The Black Death in England and Egypt: A Comparative Study* (Cairo: American University Press)

Bowman, Alan K., and Eugene Rogan (eds.). 1999. *Agriculture in Egypt from Pharonic to Modern Times* (Oxford: Oxford University Press)

Buckley, B. M., K. J. Anchukaitis, D. Penny, R. Fletcher, et al. 2010. “Climate as a Contributing Factor in the Demise of Angkor, Cambodia,” *Proceedings of the National Academy of Sciences* 107, no. 15: 6748–52

Carmichael, Ann G. 2014. “Plague Persistence in Western Europe: A Hypothesis,” *The Medieval Globe* 1: 157–191

Chandler, David. 2007. *A History of Cambodia*, 4th ed. (Boulder, CO: Westview Press)

Clot-Bey, Antoine Barthélemy. 1840. *Aperçu général sur l’Égypte* (Paris: Fortin, Masson)

Conrad, Lawrence. 1981. “The Plague in the Early Medieval Near East” (PhD dissertation, Princeton University)

Cooper, R. S. 1973. *Ibn Mammati’s Rules for the Ministries: Translation with Commentary of the “Qawānin al-Dawāwīn”* (PhD dissertation, University of California, Berkeley)

Description de l’Égypte ou recueil des observations et des recherches qui ont été faites en Egypte pendant l’expédition de l’armée française. Atlas géographique. 1828. 2nd ed., France, Commission des monuments d’Égypte (Paris: Imprimerie de C. L. F. Panckoucke)

DeWitte, Sharon N. 2014. “The Anthropology of Plague: Insights from Bioarcheological Analyses of Epidemic Cemeteries,” *The Medieval Globe* 1: 97–123

Diamond, Jared. 2011. *Collapse: How Societies Choose to Fail or Succeed* (London: Penguin)

Dols, Michael. 1977. *The Black Death in the Middle East* (Princeton, NJ: Princeton University Press)

Dols, Michael. 1979. “The Second Plague Pandemic and its Recurrences in the Middle East: 1347–1894,” *Journal of the Economic and Social History of the Orient* 22: 162–89

Dols, Michael. 1981. “The General Mortality of the Black Death in the Mamluk Empire,” in *The Islamic Middle East, 700-1900: Studies in Social and Economic History*, ed. Abraham Udovitch, 397–428 (Princeton, NJ: Darwin Press)

Evans, D., C. Pottier, R. Fletcher, S. Hensley, et al. 2007. “A Comprehensive Archaeological Map of the World’s Largest Preindustrial Settlement Complex at Angkor, Cambodia,” *Proceedings of the National Academy of Sciences* 104, no. 36: 14277–82

Fletcher, R., D. Perry, D. Evans, C. Pottier, et al. 2008. “The Water Management Network of Angkor, Cambodia,” *Antiquity* 82: 658–70

Hennequin, Gilles. 1974. “Points de vue sur l’histoire monétaire de l’Égypt musulmane au moyen-âge,” *Annales islamologiques* 12: 1–36

Hennequin, Gilles . 1977. “Nouveaux aperçus sur l’histoire monétaire de l’Égypt à la fin du moyen-âge,” *Annales islamologiques* 13: 179–215

Higham, Charles. 2002. *The Civilization of Angkor* (Berkeley: University of California Press)

Igarashi, Daisuke. 2006. “The Establishment and Development of al-Diwan al-Mufrad: Its Background and Implications,” *Mamluk Studies Review* 10: 117–40

Igarashi, Daisuke. 2008. “The Private Property and Awqaf of the Circassian Mamluk Sultans: The Case of Barquq,” *Society for Near Eastern Studies in Japan* 63: 167–93

Igarashi, Daisuke. 2010. “The Evolution of the Sultanic Fisc and *al-Dhakhira* during the Circassian Mamluk Period,” *Mamluk Studies Review* 14: 85–108

Igarashi, Daisuke. Forthcoming. *Land Tenure, Fiscal Policy, and Imperial Power in Medieval Syro-Egypt* (Chicago: Middle East Documentation Center)

Jacotin, Pierre. 1826. *Description de l’Égypte, ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l’expedition de l’armée française. Atlas géographique dédiée au Roi*, 2nd ed. (Paris: Imprimerie de C. L. F. Panckoucke)

James, J. 1995. “Shuttle Radar Maps Ancient Angkor,” *Science*, n.s., 267, no. 5200: 965

Kummu, M. 2009. “Water Management in Angkor: Human Impacts on Hydrology and Sediment Transportation,” *Journal of Environmental Management* 90, no. 3: 1413–21

Le Père, Gratien. 1818. *Mémoire sur la ville d’Alexandrie* (Paris: Imprimerie royale)

Lopez, Robert, Harry Miskimin, and Abraham Udovitch. 1970. “England to Egypt, 1350-1500: Long Term Trends and Long Distance Trade,” in *Studies in the Economic History of the Middle East*, ed. Michael Cook, 93–128 (London: Oxford University Press)

Louiseau, Julien. 2011. *Reconstruire la maison du sultan, 1350–1450: ruine et recomposition de l’ordre urban au Caire* (Cairo: Institut français d’archéologie orientale)

Meloy, John. 2001. “Copper Money in Late Mamluk Cairo: Chaos or Control?,” *Journal of the Economic and Social History of the Orient* 44: 293–321

Michel, Nicolas. 2002 “Villages désertés, terres en friche et reconstruction rurale en Égypte au début de l’époque ottomane,” *Annales islamologiques* 36: 197–251

Mikhail, A. 2008. “The Nature of Plague in Late Eighteenth-Century Egypt,” *Bulletin of the History of Medicine* 82, no. 2: 249–75

Mikhail, A. 2011. *Nature and Empire in Ottoman Egypt* (Cambridge: Cambridge University Press)

Mikhail, A. 2013. “Plague and Environment in Late Ottoman Egypt”, in *Water on Sand: Environmental Histories of the Middle East and North Africa*, ed. A. Mikhail, 111–32 (Oxford: Oxford University Press)

Moore, E. 1989. “Water Management in Early Cambodia: Evidence from Aerial Photography,” *Geographical Journal* 155, no. 2: 204–14

Morberg, A. 1915. “Regierungs Promemoria eines egyptischens Sultans,” in *Festschrift Eduard Sachau zum siebzigsten Geburtstage*, ed. Gotthold Weil, 406–21 (Berlin: Reimer)

Mujani, W. K. 2008. “Sources for the Economic Decline of the Circassian Mamluks in Egypt (872–922AH/1468–1517CE): Are They There?,” *Islamic Quarterly* 52: 161–77

Mujani, W. K. 2011. “The Nile and Irrigation during the Mamluk Period (1468–1517),” *Australian Journal of Basic and Applied Sciences* 5, no. 9: 2264–68

Naṣir, ‘Āmr Najīb Mūsā. 2003. *al-Ḥayāt al-iqtiṣādiya fī Miṣr al “Asr al-Mamlūkī”* (Ammān: al-Shurūq)

Pamuk, Sevket. 2007. “The Black Death and the Origins of the “Great Divergence” across Europe, 1300–1600,” *European Review of Economic History* 11: 289–317

Pamuk, Sevket, and Maya Shatzmiller. 2014. "Plagues, Wages, and Economic Change in the Islamic Middle East 700–1500," *Journal of Economic History* 74: 196–229

Panzac, Daniel. 1978. "Alexandrie: évolution d'une ville cosmopolite au XIXe siècle," *Annales islamologiques* 14: 195–215

Panzac, Daniel. 1987. "Alexandrie, peste et croissance urbaine (XVIIe-XIXe siècles)," *Revue de l'Occident musulman et de la Méditerranée* 46: 81–90

Penny, D., C. Pottier, M. Kummu, R. Fletcher, et al. 2005. "Hydrological History of West Baray, Angkor, Revealed through Palynological Analysis of Sediments from the West Mebon," *Bulletin de l'École française d'Extrême Orient* 92: 497–521

Petry, Carl. 1994. *Protectors or Praetorians? The Last Mamluk Sultans and Egypt's Waning as a Great Power* (Albany: State University of New York Press)

Popper, William. 1954–63. *History of Egypt, 1382–1469 A.D.*, 4 vols. (Berkeley: University of California Press)

Rappaport, Yosef, and Ido Shahar. "Rural Society in Medieval Islam: 'History of the Fayyum'" <http://www2.history.qmul.ac.uk/ruralsocietyislam/index.html>

Rivlin, Helen. 1961. *Agricultural Policy of Muhammad 'Ali in Egypt* (Cambridge, MA: Harvard University Press)

Sabra, Adam. 2000. *Poverty and Charity in Medieval Islam* (Cambridge: Cambridge University Press)

Said, R. 1993. *The River Nile: Geology, Hydration, and Utilization* (Oxford: Pergamon)

Schultz, Warren. 1995. "Mamluk Money from Baybars to Barquq: A Study Based on the Literary Evidence and the Numismatic Evidence" (PhD dissertation, University of Chicago)

Schultz, Warren 1998. "The Monetary History of Egypt, 642-1517," in *The Cambridge History of Egypt, Volume I: Islamic Egypt, 640–1517*, ed. Carl Petry, 318–38 (Cambridge: Cambridge University Press)

Schultz, Warren. 2011. "Recent Developments in Islamic Monetary History," *History Compass* 9: 71–83

Shatzmiller, Maya. 2012. "The Economic History of the Medieval Middle East: Strengths, Weaknesses, and the Challenges Ahead," *International Journal of Middle East Studies* 44: 529–31

Shaw, Stanford J. 1962. *The Financial and Administrative Organization and Development of Ottoman Egypt* (Princeton, NJ: Princeton University Press)

Shoshan, Boaz. 1983. "Money Supply and Grain Prices in Fifteenth Century Egypt," *Economic History Review* 36: 47–67

Silverstein, Adam J. 2007. *Postal Systems in the Pre-Modern Islamic World* (Cambridge: Cambridge University Press)

Söderberg, Johan. 2006. "Grain Prices in Cairo and Europe in the Middle Ages," *Research in Economic History* 24: 189–216

Stanley, D. J., and A. G. Warne. 1998. "Nile Delta in its Destruction phase," *Journal of Coastal Research* 14, no. 3: 794–825

Stone, R. 2006. "The End of Angkor," *Science* 311, no. 5766: 1364–68

Stone, R. 2009. "Tree Rings Tell of Angkor's Dying Days," *Science* 323, no. 5917: 999

Thayer, Jennifer M. 1993. “Politics and Power Networks in Ancient Egypt” (PhD dissertation, New York University)
Tsugitaka, Sato. 1977. *State and Rural Society in Medieval Islam: Sultans, Muqta’s, and Fallahun* (Leiden: Brill)
Varlık, Nükhet. 2014. “New Science and Old Sources: Why the Ottoman Experience of Plague Matters,” *The Medieval Globe* 1: 193–227
Ward, P. N. 1993. “Systems of Agricultural Production in the Delta,” in *The Agriculture of Egypt*, ed. G. M. Craig, 229–64 (Oxford: Oxford University Press)
White, Sam. 2010. “Rethinking Disease in Ottoman History,” *International Journal of Middle East Studies* 42: 549–67
Willcocks, William. 1913. *Egyptian Irrigation*, 3rd ed., 2 vols. (London: Spon and Chamberlain)
al-Zāmil, Muhammad Fathī. 2008. *al-Taḥawwulāt al-’iqtiṣ ādīyah fī Miṣr ‘awākhir al-‘Uṣūr al-Wusṭá* (Cairo: al-Majlis al-A‘lá lil-Thaqāfah)

Stuart Borsch (sborsch@assumption.edu) is an associate professor of history at Assumption College in Worcester, Massachusetts. His primary field of research is the economic history of the medieval Islamic world. Among his previous works is *The Black Death in Egypt and England* (2005), a study aimed at explaining how plague depopulation produced different economic outcomes for two countries, Egypt and England. Whereas England was able to recover from the Black Death, it is clear that Egypt did not, and the root cause was the difference in social structure and landholding practices. Borsch now works on projects related to the Egyptian irrigation system. Most recently, he finished a piece on the history of the Alexandria canal during the medieval and early modern periods. He is also studying long-term changes in the irrigation system of the province of al-Buḥayra. Other recent work focuses on historical changes in the rural markets of Egypt and monetary disruption following the Black Death.

Abstract Starting with the Black Death, and continuing over the century and a half that followed, plague depopulation brought about the ruin of Egypt’s irrigation system, the motor of its economy. For many generations, the Egyptians who survived the plague therefore faced a tragic new reality: a transformed landscape and way of life significantly worsened by plague, a situation very different from that of plague survivors in Europe. This article looks at the ways in which this transformation took place. It measures the scale and scope of rural depopulation and explains why it had such a significant impact on the agricultural infrastructure and economy.

Keywords Medieval Egypt, irrigation, plague, depopulation, economic decline, agrarian economy.